

# **IEA/SolarPACES**

## **Task I: Electric Power Systems**

### **Task Meeting Summaries:**

**Cuernavaca, Mexico**

**28 October 98**

**Kibbutz Shefayim, Israel**

**1 July 99**

### **Task I Program of Work, 1999**

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**Operating Agent, Task I**

# **Sandia National Laboratories**

Albuquerque, New Mexico 87185-0703

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## **IEA/SolarPACES Task I Participants:**

Since the last task meeting summaries published in May, 1998, we have had two IEA/SolarPACES Task I: Electric Power Systems task meetings: one in Cuernavaca, Mexico on 28 October 1998, and one at Kibbutz Shefayim, Israel, on 1 July 1999. Please find enclosed my summaries of these meetings. The table below provides a snapshot of Task I at this time, including all activities currently underway and defined in our recent Program of Work input to the ExCo in Santa Fe, NM, USA in November 1999.

## **Task I: Electric Power Systems (C. E. Tyner, Operating Agent)**

### **Sector 1. Central Generation Systems**

- System Operations and Maintenance Cost Reduction
- DIrect Solar Steam (DISS)
- THESEUS Project
- EuroTrough
- Solar Two Final Evaluation
- 10-MW Solar Thermal Power Plant for Southern Spain (PS10)
- Solar Gas Turbine with Tower Reflector
- Hybrid Power Plant Assessment

### **Sector 2. Distributed Generation Systems**

- Dish/Brayton Project
- Stirling Engine Exchange Program
- SAIC USJV Project
- Dish Engine Critical Components Projects
- Remote Dish/Stirling Water Pumping System Development
- Remote Dish System Development
- EuroDish

### **Sector 3. START Missions**

- START Missions
- Industry START Missions
- Egypt/WB Support (NREA Parabolic Trough Collector Testing)
- Brazil/GEF Support

### **Sector 4. Market Barriers and Opportunities**

- Identification and Evaluation of Market Barriers
- Database of Project and Market Opportunities
- Technology Roadmapping
- STEPS - Expert System for Solar Thermal Power Stations
- SYNTHESIS - Private Support of Solar Thermal Power Projects
- SolWin/RENIP Plan
- Life Cycle Assessment (LCA) of STE Power Stations

Thanks for your active participation in Task I activities and for helping expand our areas of cooperation.

Sincerely,

Craig E. Tyner  
Operating Agent, Task I

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**28 October 98**

*(in conjunction with Task III meeting)*

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### **Kibbutz Shefayim, Israel**

**1 July 99**

*(in conjunction with Task III meeting and tour of the Weizmann Institute of Science)*

- Meeting Summary
- Detailed Meeting Minutes
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## **Task I Program of Work 1999**

## **IEA/SolarPACES Task I Distribution**



# IEA/SolarPACES Task I Meeting: Solar Thermal Electric Power Systems

1 July 1999  
Kibbutz Shefayim, Israel

## Meeting Summary

The Task I meeting covered current activities in all four sectors, with particular emphasis on industry involvement in future START Missions and resolution of issues associated with hybrid operation of future trough plants in India and Egypt.

## Task I Meeting

Craig Tyner convened the meeting, and indicated the intent to cover, along with regular agenda and Sector items, brief discussions of a Program of Work (POW) update, the i-START issue, and the hybrid issue. An agenda and attendance list is attached. 30 people attended, including representatives from all SolarPACES members except Brazil.

## Sector 4: Market Barriers and Opportunities (Tom Williams, Sector Leader)

**Discussion of Status of Recent Opportunities, T. Williams, SunLab:** Tom Williams led Sector 4: Market Barriers and Opportunities discussions. He covered the status of GEF activities, including trough prospects for India, Egypt, Morocco, Mexico, and Crete. He summarized the GEF Cost Reduction Study (part of GEF Program 7 long-term cost reduction, versus Program 6 aimed at reducing barriers and small scale implementation). Towers were used as generic advanced technology. The bottom line: good technology, worth investing in. The first phase would be about 9 projects, 750MW, \$750M in support, with an 11¢/kWh target. The second phase would be 3GW, \$1-2B investment, 8¢ target, while the third phase would be 4-50GW, and would be competitive if carbon credits exist. Final recommendations were to make a clear commitment; define targets; and work for carbon credits and reduction of trade and tax barriers. A copy of viewgraphs from the study is attached, and the full document can be downloaded from the SunLab web site (<http://www.eren.doe.gov/sunlab/>).

**Eskom/SABRE-Gen, L. Van Heerden, Eskom:** Louis Van Heerden discussed issues in South Africa and Eskom. CSP-Africa is looking at large-scale power (and also dish/engine for distributed applications), including feasibility studies. Their PDF project has been accepted by the GEF as a medium-sized project. Eskom has low energy production costs, but growing environmental concerns because of their reliance on coal. The SABRE-Gen program is aimed at evaluation of renewables for SA. There are currently two projects: Wind and Solar Thermal Electricity. They will consider distributed applications for CSP later; in current study they will be looking at larger-scale grid connected systems. CSP-Africa study is the name for the solar thermal electric project under SABRE-Gen. This project will start with a screening analysis to weed out concepts that don't make sense for their application. They will then develop conceptual designs and evaluate them. Project approval has taken about a year. The final approval looks assured at this point. They envision starting the project in August, completing in July 2000. At that time they want to be in a position to move forward fairly rapidly with a plant build. A 50 MW solar plant is a very small plant for Eskom. They are used to deploying in 4 GW increments.

**Project Opportunity Database, T. Williams, SunLab:** Tom Williams discussed the Project Database activity (including offer for SunLab coordination). A contact will be named for each activity; the database will contain only public information; and it will be updated prior to each ExCo.

**Advances in Public and Political Awareness of CSP Technologies in Spain, M. Blanco, CIEMAT:** Manuel Blanco gave an update on the Spanish situation. (He will provide a copy of the Royal Decree.) There has been a lot of public education and political awareness activities in Spain that were critical to moving forward with this effort. The premium for project deployment will continue forever, but there is the option to modify the amount in the future. The amount of the premium will vary according to the type of technology. Primary emphasis will be on 50 MW plants or less (there is a much smaller incentive available for larger plants). Hybrid decisions are still evolving. It has been proposed to provide total incentives to plants using up to 10% fossil fuel, and perhaps allow payment on solar energy for plants that are up to 50% hybrids. Facilities have to use solar as their primary energy source. There are no foreign ownership issues. The electricity must be acquired by the closest distributor at the required price. For plants smaller than 5 kW, seller can get \$0.39/kWh premium (assuming total capacity nationally doesn't go beyond 50 MW). For other solar facilities, the premium is \$0.195/kWh (in both cases on top of a base of 4¢/kWh). The revision in the premiums will take place every 4 years. There was considerable discussion around the risk of changing the level of support. Manuel stated that the modifications could affect existing contracts, but that this has not stopped development of many wind projects under similar situations. There recently was a forum on Andalucia in the next century. Manuel participated in the panel, which recognize the importance of solar thermal and harnessing the resource that was available in Andalucia. Press coverage of CSP has picked up in the last year. Manuel showed tracking of press coverage, which has reached 1.2 M people in last year. Manuel will provide a VG on the process (a checklist).

**Near-Term Solar Power System Cost Evaluation, A. Roy, Ben Gurion University:** Aharon Roy made a brief presentation (actually part of Task III, but presented here because of unavailability on Saturday) on near-term solar power system cost evaluation. The interesting approach theorized a general balance-of-plant cost of \$400/m<sup>2</sup> for PV, CSP, and hot water. The difference in cost between systems was in the solar specific part of the plant: \$500 for PV; \$20 for CSP; and \$10 for hot water.

### **Sector 3: START Missions (Craig Tyner for Greg Kolb, Sector Leader)**

In the absence of Geyer and Kolb, Tyner led Sector 3: START Mission discussions.

**BG Power Generation Briefing – London, C. Tyner, SunLab:** Tyner described the mini-START Mission meeting at BG Power technologies in November 1998. They had a lot of interest in solar reforming, and this has resulted in discussions of a joint proposal between BG and Weizmann to the EU in this area. Regarding large CSP systems, BG noted that an integrated supplier is needed, and that might be an area they would be involved in.

**Follow-on Activity in Egypt, S. Zannoun, NREA:** Zannoun described the follow-on Egypt activity. An RFP is now expected to be on the street by Feb 2001. Phase I of consultant effort (Lahmeyer International) is aimed at completing economic analysis and more accurate estimates of project cost. The consultant in the next Phase will be responsible for preparing the RFP. They would like to have financial closure by May 2001, allowing construction of the plant to be completed by 2003. Plans are to start a second plant in 2001, and then provide a series of plants after that. All of the plants after the initial plant would be 300 MW size (hybrids for the first plants at least). While the first two plants will be trough hybrids, Egypt would expect to deploy the best available technology as it became available. The government plans to provide extended support to the projects.

**Mission to Ghana, M. Epstein, WIS:** Epstein described his mini-START Mission to Ghana. The main

fuel in region is natural gas from Nigeria. Plans are being discussed for upgrading gas supply lines in region. Main current sources of electricity are hydro, provided by two plants totaling 1072 MW. Hydro has potential for another 700 MW but would be fairly expensive at prices of 6.9-12.6¢/kWh. In 1998, low inflow to reservoirs greatly reduced the level of productions, cutting output 300 MW. There are some structural causes of energy problems in Ghana: past under-pricing of energy, over dependence on hydro, etc. Actions to correct include the natural gas pipeline, construction of a 220-MW oil fired plant, and application of diesels by industry for backup power supply. Ghana has good solar resource and a reasonable infrastructure available. The government is interested in 30-80 MW CSP plants, and the concept of integrating them with hydro is interesting. Epstein's report is included in the Task meeting reports.

**Additional 1999 START Mission options, C. Tyner, SunLab:** We then discussed future START missions and involvement of industry. The ExCo previously decided that SolarPACES should not be endorsing some specific industry partners or their recommendations, i.e., SolarPACES needs to maintain objectivity.

Grasse recommended that we need to follow up on existing requests from Costa Rica, Uzbekistan, and Zimbabwe. Argentina and Chile are also potential applications. Louis Van Heerden commented on Zimbabwe, saying that he had some contacts there, and it didn't really look that interesting to him. Kolb will pick up responsibility for deciding future directions.

Finally, Avi Brenmiller, Solel, made the suggestion off-line that we might want to prepare a set of data tables of START mission results, as these would be particularly of use to industry.

## **Sector 1: Central Generation Systems (Wolfgang Meike, NTCER, Sector Leader)**

Meike led discussions of Sector 1: Central Generation Systems. He first summarized the status of the 10th Symposium in Australia in March, 2000.

**Theseus project update, C. Tyner, SunLab for R. Kistner:** Tyner presented a brief status of the THESEUS project in the absence of Rainer Kistner. Assuming EU final decisions on the project, construction of the solar plant is expected to begin in 2001, completing in 2002. Solel has licensed the group to use their trough designs in the bid.

**DISS / EuroTrough / Parex updates, M. Romero (for E. Zarza), CIEMAT:** Manuel Romero (for E. Zarza) presented the status of DISS. The DISS project is aimed at developing a direct steam generation trough. Phase 1, construction, was completed 11/30/98; final reports to the EU were made in 3/99, and indicated a 25% cost reduction possible. Phase 2, testing, started in December. Project received critical review by the EU with good feedback. Tilt on the collectors can be adjusted between 0 and 4 degrees, with some collectors able to be tilted to 6 or 8 degrees. Unexpectedly large thermal inertia of passive piping (not the HCEs) and wall thermocouple heating by the sun are problems experimentally. Initial optical efficiency measurements are about 80%, with thermal efficiency of about 70%. The project is scheduled to be completed in mid-2001.

**PS 10: 10 MW Solar Tower Power Plant for Southern Spain, M. Romero, CIEMAT:** Romero also described the PS10 project for a PHOEBUS-like plant in Spain. The plant will produce 20GWh/year (solar only, with 23% capacity factor). The objective is a cost less than \$2700/kW. The plant will use 885 90-m<sup>2</sup> heliostats (costing about \$138/m<sup>2</sup>). The 50MWt receiver will be 132m<sup>2</sup> (operating at 680C), costing less than \$54/kWt, and will be a half cylinder design with a north field. There will be 30MWh of air/aluminum thermal storage. The O&M staff is expected to be 10-12. The plant will be located 15km west of Seville (Sanlucar la Mayor). The total budget is \$30M, with 30% for heliostats. Tenders are expected by 10/99, with operation in 2002.

**Solar Tres: 10 MW Solar-only 24-hr Solar Tower Plant for Southern Spain, M. Blanco, CIEMAT:**

Manuel Blanco then described the proposed Solar Tres project. It will be 10 MWe (equivalent of about 30MW with a solar multiple of 2.6) molten salt technology demonstrated at Solar Two, with 12h of storage. The 95-MWt receiver will be a billboard, with a north field of 7842 heliostats (19m<sup>2</sup>). Peak flux will be 900 kW/m<sup>2</sup>. The project is estimated to cost \$53M, with a 36 month design/build period.

**Tower Reflector / CONSOLAR update, M. Epstein, WIS:** Epstein then summarized the Israeli beam-down work, after introducing Uri Fisher as the new national coordinator for Task I. The tower mirror is 73m<sup>2</sup>, 1.2 MWt. The CPC has a 2.2m diameter inlet. The 500-kWt receiver can operate at high pressure (up to 20 bar, and high temperature). The piping and connections are being completed. Phase 1 operation (without the turbine) will be completed by 3/2000, while operation with the turbine will run through 10/2000. Finally, Epstein also described briefly their ongoing concentrating PV work, with 500-1000 sun capability and about 20% efficiency. They will have 1kW modules for small systems, but are already testing a 5kW module on-sun. A tour of the facility is scheduled for Sunday.

**Update on Australia's Solar Thermal Activities, W. Meike, NTCER:** Meike then gave a summary of the Australian activities, moved to Sector 1 because it is central generation even though dishes or CLFR are used. The "Showcase" projects effort awarded \$6.5M to 5 projects, with total value of \$45M. Two solar thermal projects were submitted, and both were funded, receiving \$1.3M each.

The first project is based on the "Big Dish," and headed by Stephen Kaneff. Anutech is doing research; Pacific Power, engineering and utility; and Transfield, construction. There will be 18 dishes providing 535C steam to a 2 GW coal plant. The steam will be delivered directly to the turbine. The power station is in Rockhampton.

The second project uses compound linear fresnel reflectors (CLFR) of David Mills design. Solsearch (U. of Sydney), Austra Electric (engineering, utility), Stanwell corporation (Power Station, engineering) are involved. Glass reflectors are 9m long x 1.5m wide and track the sun. 15-m towers support the evacuated receiver with secondary. Ground coverage is a dense 80%. Total reflector area is 17,000 m<sup>2</sup>, for total of 13 MWt. First step will feed in 180C hot water to system at the 3 MWe equivalent. In step two, temperatures will increase to 280C, go to feedwater heaters, and provide the equivalent of 4.2 MWe. Potential would be 120 MW at this particular plant. A possible third step has no firm plans, but could inject steam to main steam drum, potential 500 MW at this plant. A prototype receiver is operational at U. Sydney. Construction is planned to begin in 1999, operation in 2000. Contracts are currently being signed.

The Prime Minister has announced a 2% renewables initiative. It includes a wide range of renewables, including new large hydro. It will be binding by 2008 at earliest, 2010 likely. It requires 2% of all electricity sold (so doesn't include cogen) to be new renewables, and will be about 10,000 GWh/year. Likely technologies that will be used are biomass, wind, and (maybe) CSP (depending on whether there will be enough left over of the mandate after biomass and wind). Hydro doesn't look to be attractive because of environmental objections.

Finally, Meike described the Whyalla pre-feasibility study. It is based on big dish for power generation and desalination. Whyalla is in South Australia, and has grid and water by pipeline. The project is funded from private sources. Solar insolation is 2,200 kWh/m<sup>2</sup>y. The project would use 200 big dishes, a 24MW GT combined cycle, while the desalination side is the main reason for the project. The project predicts power will cost 3.3-4.6¢/kWh, also producing 20Ml/d of water at \$0.53/kl, where industrial clients are currently paying \$1.30/kl (non-industrial users now pay \$0.60/kl for water costing \$1.70/kl).

**Solar Two update, C. Tyner, SunLab:** Craig Tyner presented a brief overview of the status of final evaluation and documentation of the Solar Two project. Solar Two met essentially all of its original objectives, including simulating the design, construction, and operation of the first commercial plants;

validating technical plant characteristics; improving accuracy of economic projections; distributing information to foster interest in commercialization; and stimulating formation of a commercial consortium. Despite extended start-up difficulties, most technical metrics were also achieved. Follow-on commercial activities are described above for Solar Tres.

**Hybrid Plant Assessments, C. Tyner, SunLab:** Tyner then led a discussion of how to handle analysis of the hybrid issue brought to light with the Indian and Egyptian projects. A team will be formed to analyze options, ultimately leading to a SolarPACES position paper on the issue. Greg Kolb will help with coordination, with Robert Pitz-Paal taking leadership for coordinating European contributors. Other participants will include Wolfgang Meike, Manuel Blanco, Hans Fricker, Sami Zannoun, Paul Kesselring, Hank Price, and Michael Geyer. They will shoot for early August for an understanding of where we are on the Egypt project, and suggest alternatives.

## **Sector 2: Distributed Generation Systems (Tyner for T. Mancini, SunLab, Sector Leader)**

Tyner (in the absence of Tom Mancini) led Sector 2: Distributed Generation discussions. Tyner also presented the status of US activities, including the SAIC joint venture, the Boeing DECC project, and the 10kW remote power project.

**Distal II / EuroDish update, P. Heller, DLR/PSA:** Peter Heller covered the status of the Distal II/EuroDish activities. EuroDish is aiming at moving the dish into commercial applications for remote markets. The project will build, test, and operate two units at the PSA. The cost goal is \$5000/kW at 100 units per year. The primary aim is cost reduction. All of work builds off of the Distal II units. Distal I operated for 28,000 units on 3 dishes. Distal II has now operated 2000 hours on three units. Distal II went to a larger concentrator, provides excess power at noon but produces full power over greater period of day so more net kWh during the year. During excess heat periods a fan provides receiver cooling. Distal II went to an az/el drive. Total cost of Distal II was \$12,000/kW for the three dishes installed at PSA. Costs were split 37% on-site installation, 23% engine, 14% controls, and 15% dish hardware. They are trying to use beam control for feedback, but it is not working as yet. EuroDish modifications will include changes to drives and system controls.

**U. S. USJVP (SAIC) and DECC (Boeing) update, C. Tyner, SunLab:** Both the SAIC and Boeing activities continue. SAIC's 25-kW Phase II system is typically operating within 80-90% of its design performance, and has over 1200 hours of solar operation. SAIC is continuing system testing, development of improvements, and pursuit of market opportunities (particularly in the U. S.). Boeing currently has 2 systems operating in California, as well as a gas-fired engine running at Kockums. They have over 2000 hours of operation on sun, and have had over 96% system availability since July, 1998. They also continue to pursue U. S. markets.

**10-kW Remote Power Project, C. Tyner, SunLab:** SunLab has been (since October 1998) developing a 9-kW remote power system utilizing the Solo Stirling engine and advanced concentrator and controls technology developed over the past several years in the U. S. System testing (on-grid) was successfully initiated in the summer of 1999, and development continues. The system is expected to be fully remote-capable and operating in a remote application in the U. S. by fall of 2000.

## **Next Meetings:**

The next Task I meeting will be held in conjunction with the 10<sup>th</sup> International Symposium on Solar Thermal Concentrating Technologies (and ExCo, Task II, and Task III meetings), in Sydney, Australia, on March 15, 2000.

The following meeting of Task I is tentatively scheduled to be held in conjunction with the ExCo meeting in Cairo, Egypt, on September 23, 2000. Task II and Task III meetings will likely not be held at this time.

## **Task I Meeting Action Items (all designated 9907-#):**

1. All projects leads will update program of work. Expect this to be a 5-60 min exercise
2. Avi Brenmiller volunteered to provide an outline of the data he felt should be summarized from START missions
3. Tom Williams will provide a skeleton of project database. Will add the new projects discussed here today.
4. Everyone needs to email presentation to Craig so he can get minutes out.
5. Kolb and Pitz-Paal will organize the hybrid activity and arrange a workshop to finalize results.
6. Tyner will assess whether we need a concentrating PV activity.
7. Tyner will change national coordinators to Uri Fisher (Israel) and Manuel Romero (Spain).

## Appendix A: Meeting Agenda

### IEA/SolarPACES Task I: Electric Power Systems

#### Task Meeting

Kibbutz Shefayim, Israel

Thursday, July 1, 1999

#### Agenda

(Updated after meeting)



09:00	<b>Introduction and Opening Remarks (Craig Tyner, Operating Agent)</b> Sector Leader options (Kolb replaces Geyer in Sector 3; do we need changes in other sectors?)	
09:30	<b>SECTOR 4: Market Barriers/Opportunities (Tom Williams)</b> Discussion of Status of Recent Opportunities	Tom Williams, moderator
	<ul style="list-style-type: none"><li>• GEF (India, Morocco, Egypt, Mexico)</li><li>• Spain, Australia, Brazil, USA, Others??</li><li>• Eskom/SABRE-Gen – Van Heerden</li><li>• GEF Cost Reduction Study and Future Plans</li><li>• New ideas for collaborative projects</li></ul>	
	Project Opportunity Database	T. Williams
	Advances in Public and Political Awareness of CSP Technologies in Spain	M. Blanco
	Near-Term Solar Power System Cost Evaluation	A. Roy
11:30	<b>SECTOR 3: START Missions (Craig Tyner for Greg Kolb)</b> BG Power Generation Briefing – London	C. Tyner
	Follow-on Activity in Egypt	S. Zannoun
	Mission to Ghana	M. Epstein
	Additional 1999 START Mission options?	C. Tyner
	Changes to START Mission charter? i-START?	C. Tyner
13:00	LUNCH	
14:00	<b>SECTOR 1: Central Generation Systems (Wolfgang Meike)</b> Theseus project update	C. Tyner for R. Kistner
	DISS / EuroTrough / Parex updates	E. Zarza
	PS 10: 10 MW Solar Tower Power Plant for Southern Spain	M. Romero
	Solar Tres: 10 MW Solar-only 24-hr Solar Tower Plant for Southern Spain	M. Blanco
	Tower Reflector / CONSOLAR update	M. Epstein
	Update on Australia's Solar Thermal Activities	W. Meike
	Solar Two update	C. Tyner
	Other: Hybrid Plant Assessments?	C. Tyner
15:30	BREAK	
16:00	<b>SECTOR 2: Distributed Generation Systems (C. Tyner for Tom Mancini)</b> Distal II / EuroDish update	P. Heller
	U. S. USJVP (SAIC) and DECC (Boeing) update	C. Tyner
	10-kW Remote Power Project	C. Tyner
18:00	<b>Additional Business, Action Items (Tyner)</b>	
18:30	<b>ADJOURN</b> <b>Additional Meetings: Friday, July 2, Task II and Saturday, July 3, Task III</b>	



## **Appendix B: Meeting Participants**



## **Appendix C: Presentation Summaries**